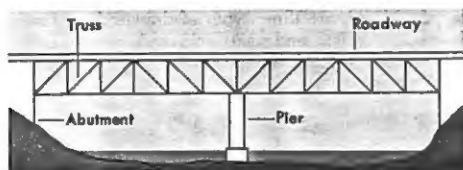


bridges ranges up to about 700 feet (210 meters).

There are two main types of girder bridges. In one type, called a *box girder bridge*, each girder looks like a long box that lies between the piers or abutments. The top surface of the bridge is the roadway. Box girder bridges are built of steel or concrete. In the other type of girder bridge, the end view of each girder looks like an *I* or a *T*. Two or more girders support the roadway. This type of bridge is called a *plate girder bridge* when made of steel, a *reinforced* or *prestressed concrete girder bridge* when made of concrete, and a *wood girder bridge* when made of wood.

**Truss Bridges** are supported by frameworks called *trusses*. The parts of the trusses are arranged in the form of triangles. Such bridges are built over canyons, rivers, and other areas. A truss bridge may have a main



Truss Bridge

span that extends more than 1,000 feet (300 meters).

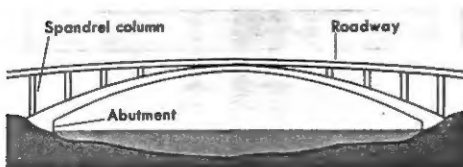
Each truss consists of steel or wood parts that are connected to form one or more triangles. The simplest truss consists of three parts fastened together at their ends to form a triangle.

Most truss bridges have one set of trusses on each side of the roadway. The majority of modern truss bridges have the roadway on top of the trusses and are called *deck truss bridges*. The roadway of a *through truss bridge* runs between the trusses.

In a *simple span truss bridge*, each truss extends between two abutments or piers. In a *continuous truss bridge*, each truss has three or more such supports.

Some locations are suitable for either a truss bridge or a girder bridge. In such cases, some engineers choose to build a truss bridge because it requires less construction material than the girder type. However, many engineers prefer a girder bridge because it is more attractive, and it is easier to construct and maintain.

**Arch Bridges** are structures in which each span forms an arch. The spans range up to about 1,700 feet (518 meters) long. The arch bridge is one of the oldest types of bridges. Early arch bridges consisted of large stone blocks wedged together to form an arch. Today, the majority of arch bridges that have short spans are made



Concrete Arch Bridge

of concrete or wood. Arch bridges with long spans are built of concrete or steel.

Engineers must design arch bridges so that the sides of the arch do not spread apart and collapse the bridge. The roadway of some arch bridges lies on top of the arch and is supported by vertical columns called *spandrel columns*. These columns transfer the load of the roadway to the arch, which bears the weight of the bridge. The roadway of a *tied arch bridge* is below the curve of the arch. The roadway is supported by girders or other types of beams that hang from the arch. The girders or beams also connect to the ends of the arch to prevent the ends from spreading out. The abutments support the weight of the bridge.



Steel Arch Bridge

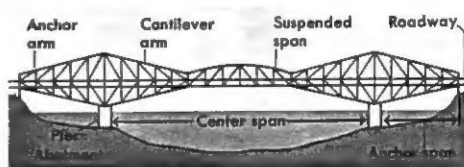
**Cantilever Bridges** consist of two independent beams called *cantilevers* that extend from opposite banks of a waterway. The two cantilevers are joined together above the middle of the waterway by a beam, girder, or truss. Cantilever bridges may have spans as long as about 1,800 feet (549 meters).

Each cantilever has two sections, an *anchor arm* and a *cantilever arm*. The anchor arm extends between an abutment and a pier. One end of the cantilever arm is supported by the pier, and the other end extends freely over the waterway. The free ends of the two cantilevers are joined together by a *suspended span*.

Most cantilever bridges have two *anchor spans* and one *center span*. Each anchor span consists of an anchor arm. The suspended span and the two cantilever arms make up the center span.

Many cantilever bridges have truss frameworks. Most bridges of the cantilever type are made of steel or prestressed concrete (see CEMENT AND CONCRETE [Prestressed Concrete]).

**Suspension Bridges** are perhaps the most impressive type of bridge because of their long main span and especially attractive appearance. These bridges have a roadway that hangs from steel cables that are supported by two high towers.



Cantilever Bridge

## Notable Bridges

Name	Location	Main Span Length		Total Length (Bridge and approaches)		Year Opened
		In feet	In meters	In feet	In meters	
Suspension						
Humber	Humber River, near Hull, England	4,626	1,410	7,283	2,220	*
Verrazano-Narrows	The Narrows, Brooklyn-Staten Island, New York, N.Y.	4,260	1,298	13,700	4,176	1964
Golden Gate	Golden Gate Strait, San Francisco-Marina County, Calif.	4,200	1,280	8,981	2,737	1937
Mackinac	Straits of Mackinac, St. Ignace-Mackinaw City, Mich.	3,800	1,158	18,615	5,674	1957
Bosporus	Bosporus (strait), Turkey	3,524	1,074	5,118	1,560	1973
George Washington	Hudson River, New York, N.Y.-Fort Lee, N.J.	3,500	1,067	4,760	1,451	1931
25th of April	Tagus River, Lisbon, Portugal	3,323	1,013	10,574	3,223	1966
New Forth Road	Firth of Forth, Queensferry, near Edinburgh, Scotland	3,300	1,006	8,244	2,513	1964
Severn	River Severn, Beachley, England	3,240	988	5,240	1,597	1966
Cantilever						
Quebec	St. Lawrence River, Ste.-Foy-St.-Nicolas, Que.	1,800	549	3,238	987	1917
Forth	Firth of Forth, near Edinburgh, Scotland	1,710	521	7,810	2,380	1890
Osaka Port	Osaka Bay, Japan	1,673	510	10,827	3,300	1974
Commodore John Barry	Delaware River, Chester, Pa.-Bridgeport, N.J.	1,644	501	13,915	4,241	1974
Greater New Orleans	Mississippi River, New Orleans, La.	1,575	480	13,428	4,093	1958
Howrah	Hooghly River, Calcutta-Howrah, India	1,500	457	2,150	655	1943
Steel Arch						
New River Gorge	New River, near Fayetteville, W. Va.	1,700	518	3,031	924	1977
Bayonne	Kill Van Kull, Bayonne, N.J.-Staten Island, N.Y.	1,675	511	8,460	2,579	1931
Sydney Harbour	Sydney-North Sydney, Australia	1,650	503	3,770	1,149	1932
Fremont	Willamette River, Portland, Ore.	1,255	383	8,063	2,458	1973
Port Mann	Fraser River, near Vancouver, B.C.	1,200	366	6,870	2,094	1964
Cable-Stayed						
Second Hooghly	Hooghly River, Calcutta-Howrah, India	1,500	457	2,700	823	*
Saint-Nazaire	Loire River, France	1,325	404	11,010	3,356	1975
Rande	Vigo Bay, Spain	1,313	400	5,146	1,569	1978
Mississippi River	Luling, La.	1,222	372	11,011	3,356	*
Düsseldorf-Flehe	Rhine River, West Germany	1,205	367	3,763	1,147	*
Continuous Truss						
Astoria	Columbia River, Astoria, Ore.-Meglar, Wash.	1,232	376	21,697	6,613	1966
Francis Scott Key	Patapsco River, Baltimore, Md.	1,200	366	9,086	2,769	1977
Concrete Arch						
Gladesville	Parramatta River, Sydney, Australia	1,000	305	1,900	579	1964
Friendship	Paraná River, Foz do Iguazu, Brazil-Paraguay	952	290	1,812	552	1965
Plate and Box Girder						
Rio-Niterói	Guanabara Bay, Rio de Janeiro-Niterói, Brazil	984	300	45,600	13,900	1972
Sava I	Sava River, Belgrade, Yugoslavia	856	261	1,348	411	1956
Combination						
Lake Pontchartrain Causeway (twin causeways)	New Orleans-Mandeville, La.			154,387	47,057	1956 & 1969
Chesapeake Bay Bridge-Tunnel	Cape Henry-Cape Charles, Va.			93,192	28,405	1964

Sources: Construction and engineering firms; government officials.

\*Under construction in 1978.

historians was an arch bridge built in Babylon about 2200 B.C. The ancient Chinese, Egyptians, Greeks, and Romans also built arch bridges, using bricks and stone as building materials.

During the Middle Ages, drawbridges were built across the moats of many castles in Europe. Truss bridges were developed in the 1500's. Most bridges were made of stone or wood until the late 1700's, when cast iron and wrought iron began to be used for such structures. Many suspension bridges that hung from wrought iron chains were built during the early 1800's. The first plate girder bridge was completed in 1847, and the modern cantilever bridge was introduced about 1870. In the late 1800's, steel became the chief material used in bridge construction.

The first bridge made with concrete was built in

1869. A short time later, builders began using reinforced concrete for bridges. During the 1930's, prestressed concrete became an important material for bridge building. The modern cable-stayed bridge was introduced in 1955.

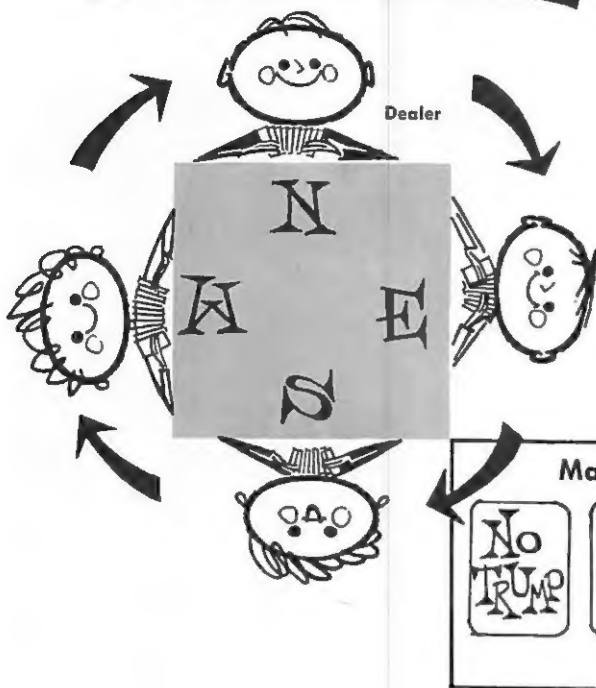
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Caisson	Peace Bridge
Cantilever	Royal Gorge
Chesapeake Bay Bridge-Tunnel	San Francisco-Oakland Bay Bridge
Eads Bridge	Triborough Bridge
Eads, James B.	Verrazano-Narrows Bridge
Engineering	Viaduct
George Washington Bridge	
Golden Gate Bridge	
London Bridge	

# BRIDGE

Partners in a Bridge Game sit opposite each other around the table. Through bidding, they try to determine the best contract possible for making game. The object of the game is to take at least enough tricks to fulfill the contract, which is called *making the bid*.



## High-Card Values



4 Points



3 Points



2 Points



1 Point

## Major Suits



Spades



Hearts

## Minor Suits



Diamonds



Clubs

**BRIDGE** is a partnership card game between two teams of two players each. Partners sit opposite each other at a table. Each player receives 13 cards. The players play one card at a time in turn. When all four have played, a *trick* is completed. A player may *win the trick* by (1) playing the highest card of the suit led, or (2) by playing the highest trump card. Each partnership tries to win as many tricks as possible.

**Contract and Auction Bridge.** *Contract* bridge is the most popular form of the game. But an older form known as *auction* bridge is still played to some extent. The fundamental difference between contract and auction bridge is that contract requires more exact bidding than auction. The object of contract bridge is to determine the best contract through bidding and to fulfill that contract in play. In auction bridge, it is not necessary to bid for game in order to score *game*. Otherwise the principles outlined for contract apply to auction.

**The Deal.** The deck is shuffled. The player sitting at the right of the dealer cuts it. The dealer deals one card in turn to each of the four players. He starts with the player on his left and deals all 52 cards in rotation.

When a deal is completed, each player picks up the cards and sorts his *hand*, separating the cards by suits: spades, hearts, diamonds, or clubs. The 13 cards of the suit are ranked ace, king, queen, jack, 10, 9, 8, and so on down to the deuce (2 spot), which is the lowest card of any suit. Playing cards are used.

**Bidding.** It is a great advantage to either partnership to be able to name the *trump* suit. Teams determine the trump suit by a process called *bidding*. Each bid is an offer to take a certain number of tricks. There are 13

tricks in each hand of bridge. The evenest possible division would give one side six tricks and the other side seven tricks.

A bid of one means, "Let me name trumps, and our side will take the *odd trick*, or seven tricks in all." The dealer has the right to the first bid. If he says "One spade," he means, "If spades are trumps, our side undertakes to win seven of the 13 tricks." If the opponent on the dealer's left now bids two hearts, he means that with hearts as trumps, his side will undertake to win eight of the 13 tricks. A *grand slam* is the highest possible bid. It means the bidder must take all 13 tricks. A *small*, or *little*, *slam* is a contract to take 12 tricks. The trump suit may be any one of the four suits, or a hand may be played in *no-trump*.

For purposes of bidding, the suits are ranked as follows: spades, hearts, diamonds, clubs. This means that a bid of three spades is higher than a bid of three hearts, which in turn is higher than a bid of three clubs. A bid of one no-trump is higher than a bid of one in any suit, but a bid of two clubs is higher than one no-trump.

If a player does not choose to bid, he says "pass." Each new bid must be higher in value than any preceding bid. If none of the players bid, the hand is not played, and the deal passes to the next player in turn. The bidding continues until there are three "passes" in a row. The last bid then becomes the contract. The person who first named the suit or no-trump which won the contract plays the hand and is called the *declarer*.

**Card Valuation.** To determine whether or not a player should bid, he must estimate the value of his cards. The point count method of valuation has made